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'SHIMMERING', THE VISUAL DISTORTION OF OBJECTS UNDERWATER AT TH--ETC(U)
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'SHIMMERING', THE VISUAL DISTORTION OF OBJECTS UNDERWATER
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AT THERMAL BOUNDARIES.

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"Shimmering", the Visual Distortion of Objects Underwater at Thermal Boundaries*

by

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On many occasions and in different areas a phenomenon here described as 'shimmering' has been observed during diving operations in water masses that have sharp thermal boundaries. Observations of this phenomenon have been made in the waters off southern California and Florida by the writer. Limbaugh, (personal communication) has observed a similar effect in the Bahamas that was so strong that underwater photographic work had to be delayed. 'Shimmering' as defined in this memorandum is the distortion of light rays as they pass through or reflect from a turbulent thermal boundary. Visual distortion is often seen on land when hot air rises from a hot pavement surface. 'Shimmering' has a similar visual effect in that there is also a distortion of the shape of objects viewed in the vicinity of the thermocline.

"Shimmering" has not been observed when thermal gradients are less than 5°F. over a distance of 5 feet of water depth. It, therefore, appears that the thermocline must be sharp for the phenomenon to take place. In many instances where "shimmering" has been observed there has also been a current shear associated with the thermocline. That is, there is a change in current

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*This memorandum has been prepared because it is believed that the existence of this phenomenon may be of considerable importance in the transmission acoustic energy through the thermocline. Distribution is intended to interested persons at NEL, The Marine Physics Laboratory, and the Scripps Institution of Oceanography.

velocity which takes place at the boundary between the water mass above and below the thermocline. This shear at the thermocline has been measured by making vertical dye streaks in the water column and observing their distortion with time (Dill and LaFond, 1956).

In southern California "shimmering" has been observed on different occasions in the coastal waters from the Mexican border in the south to as far north as Point Conception. In general, the zone of "shimmering" is only 6 inches to one foot thick and seems to be dependent on the intensity of the thermocline (Figure 1). In southern California "shimmering" is restricted to the vicinity of the thermocline and is not found at any other place in the water column.

In contrast to the observations off southern California "shimmering", observed in the Panama City, Florida area, took place within the entire water mass above the thermocline (Figure 2). On this occasion the visual distortion was observed from the surface to a depth of 50 feet which was the depth of a very sharp thermocline. At this depth there was also a sharp boundary between water currents which developed a strong current shear; the water above the thermocline had a velocity of approximately one-half a knot and the water below had a velocity that was too slow to measure. Water visibility in the Panama City region was exceptionally good during the observations having a horizontal visibility of approximately 60 feet above the thermocline and 20 feet below the thermocline.

One of the immediate questions that arises after seeing the distortion of light rays underwater in the vicinity of strong thermal gradients is, what is the effect on sound waves as they pass through this zone of "shimmering"? It may well be that some of the losses in acoustic energy observed during

operations in the field (Carsola, Dill, Schumacher and Volberg, 1956) are results of multiple refractions and scattering of sound energy by such a phenomena.

One possible explanation of the phenomenon is the turbulence set up at the thermal boundary. Small pockets or cells of relatively cold or warm water would break off into the adjacent water mass forming streamlines of different density. If this is the case the degree of turbulence might be determined from the thickness of "shimmering". The acoustical effect would likewise be related to the cell size. Approximations of zone of light distortion appear to be 2 to 6 inches although actual measurements have not as yet been made.

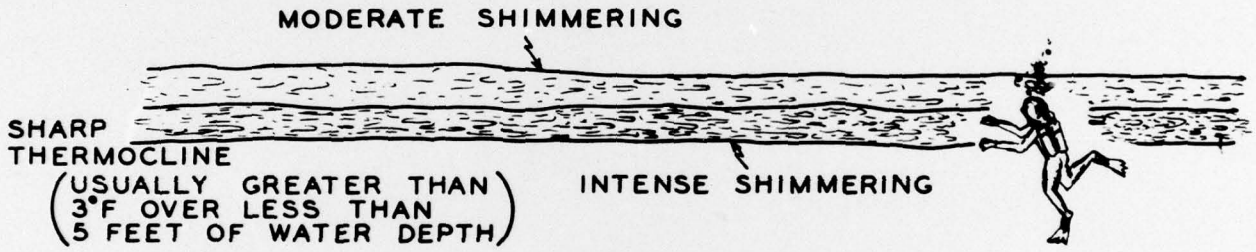
It is planned that more information will be gathered in the future as to size, shape, thermal features and effect on acoustic transmission where "shimmering" takes place.

REFERENCES

"Acoustic Barriers in Shallow Water Off San Diego," R. F. Dill and E. C. LaFond, NEL Report (manuscript) (Confidential)

"Mission Beach Mine Environmental Study," A. J. Carsola, R. F. Dill, G. P. Schumacher, and H. W. Volberg, NEL Report (manuscript) (Confidential)

WATER MASS A

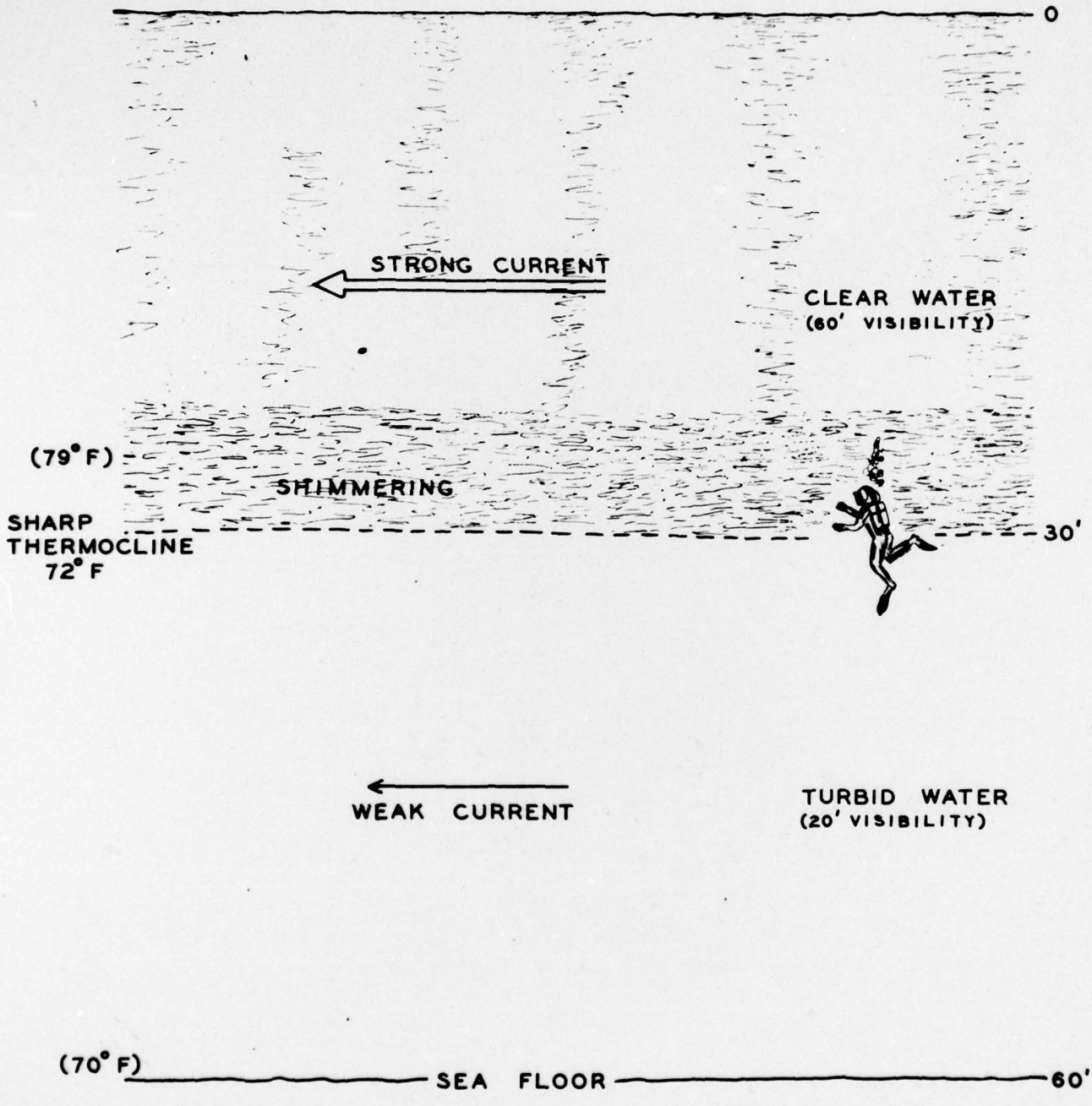


WATER MASS B

SEA FLOOR

GENERALIZED CONDITIONS COMMONLY FOUND WHEN "SHIMMERING" IS OBSERVED IN THE SOUTHERN CALIFORNIA REGION.

FIG. 1



CONDITIONS PREVAILING WHEN "SHIMMERING" WAS OBSERVED IN AN AREA OFFSHORE FROM PANAMA CITY, FLORIDA. IN THIS CASE THE ENTIRE WATER MASS ABOVE THE THERMOCLINE EXHIBITS THE "SHIMMERING" EFFECT.

FIG. 2